Remotely Measuring Mechanical Properties of Frozen Surfaces Using Indentation Methods

***Anirudh Bhat*[1] *and R. W. Neu*[1, 2]**
[1]*George W. Woodruff School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, GA, 30332*
[2]*School of Materials Science and Engineering, Georgia Institute of Technology, Atlanta, GA, 30332*

The uniaxial stress-strain curve of a material is an important mechanical property, which is required to model the response of material and structures. To get this property, a tensile test is usually conducted, which requires a large load frame and a specific test specimen. However, in certain cases this is not feasible because of the lack of material to fabricate a specimen or the inability to use a load frame. Spherical indentation has been shown to capture the complete elastic-plastic response of polycrystalline alloys from the force-displacement data. This technique has an advantage of being compact and able to test small volumes of the material compared to conventional uniaxial testing. However, due the higher hydrostatic pressure associated with the constraint of the surrounding material under the indenter tip, yielding occurs at a higher stress than it would for the same material under uniaxial load, hence the two are stress-strain curves are not the same. We have developed a model that is able to extract uniaxial stress-strain curves from indentation data and validated it on Al 7050 samples with a large variation of mechanical properties as shown in Figure 1. Europa's surface is postulated to be composed of hydrated Mg- and Na-sulfate hydrate salts mixed with water ice. The analysis of terrestrial ice has shown that their microstructures are very reminiscent of polycrystalline alloys. For this reason, the analysis procedure developed here could easily be applied to measure the uniaxial mechanical properties of Europa's icy surface. The advantage of the indentation techniques lies in the simple data collection (indentation force and depth) and specimen preparation. Furthermore, a testing fixture can be easily adapted to measure other mechanical properties such as, creep properties, fracture and impact toughness by simply changing the indenter tip, like a Swiss army knife of mechanical characterization tools.

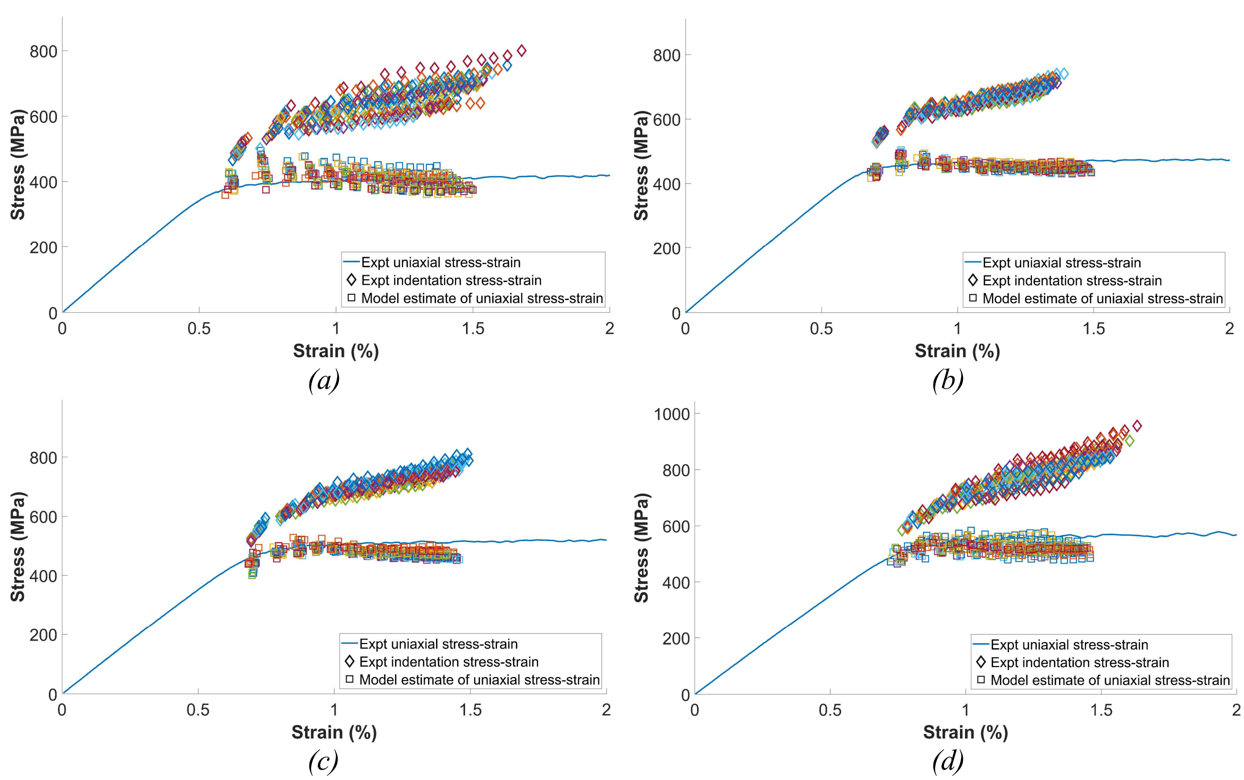

Figure 1: Predictions of uniaxial stress-strain from the experimental indentation stress-strain curves for Al 7050 with different yield strengths (a) A5 (393 MPa), (b) A2 (460 MPa), (c) D5 (500 MPa) and (d) D1(546 MPa)